SUPPLEMENT.

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FORMING A COMPLETE RECORD OF THE PROCEEDINGS OF ALL PUBLIC COMPANIES.

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The Royal School of Mines, Jermyn Street.

MR. WARINGTON SMYTH'S LECTURES.

[FROM NOTES BY OUR OWN REPORTER.]

LECTURE XLIV.—Our last lecture (said Mr. SMYTH) enabled us to take a brief glance at the different kinds of machinery employed in mining so far as water power went, but there are one or two other points to be mentioned, both as to the form of water-wheels, and as regards economy and convenience in their application. The larger wheels employed in winding and pumping are generally between 20 and 50 feet in diameter, and the breast or rim from 2 to 4 or 5 feet in width. Many of these wide-breasted wheels are somewhat remarkable, and without speaking of any of those of uncommon size in the factories of Lancashire, I may refer as examples to some of those which are to be found in the Cornish and Devonshire mining districts. Thus, if we go into the neighbourhood of Tavistock, to such famous old mines as Wheal Friendship, or to the Devon Great Consols, we shall find that the greater part of the work is done by water power, and by means of wheels varying from 6 to 14 ft. I need not, however, dwell on this particular class of wheel, because there are excellent models in the Museum, which show on a sufficiently large scale the construction of these wide wheels, which only differ from those which have less broad rims by having additional arms or spokes from the axle to support the exterior edges of the rim. These naturally have the effect of adding to the weight, and one of these wheels, 50 or 60 ft. in diameter, laden with water, has such a pull on the entire apparatus that it is necessary to take great precautions to strengthen the structure on which the wheel is to be erected, or as it is called, the wheel-pit. In countries where stone can be obtained it is built with two strong piers of masonry, on which the axle is placed, and held down through the solid mass by a bar of iron, which goes to the bottom. I need scarcely point out that any laxity in these provisions is likely to lead to extremely serious and injurious consequences, and when the whole of the pumping depends on this one wheel, it is obvious that the failure of the smallest part might stop the whole of the workings, and, perhaps, allow the water to rise in the bottom levels, so as to drown out all the workmen. When such cases occur there is sometimes difficulty in finding money to get the works dry again, and many a promising enterprise has been brought to an untimely end by an apparently trivial neglect of this kind. It is a question which occasionally leads to much controversy whether, when the works require wheel power of this great magnitude, it is better to put in one large wheel or a succession of small ones. The cost of a wheel, 10 ft. in diameter with 3 ft. breast, is from 300*l* to 400*l*., to say nothing of all the appurtenances which such a piece of machinery requires, and as the size increases to 60 or 70 ft., the expenses increase so enormously that many engineers consider it better to have two smaller wheels. The great expense of a wrought-iron axle of itself indicates how important this question may become, but you will see that when the whole of the pumping is entrusted to a single machine great risk is thereby incurred.

I will now pass on to mention briefly a few of the other machines employed in mines, not only for pumping and winding the mineral, but for dressing the ores, and I will refer, first, to a very useful application of a fall of water, where it can be got at a great height, called the water column engine *(column d'eau)*, or hydraulic pressure engine. It was formerly largely employed on the Continent, and may be seen to this day in the Hungarian mines, and particularly at Schemnitz, where the pumping is entrusted to about five of these machines. It has a cylinder into which the piston is fitted, as in the ordinary steam cylinders, and the piston is attached to the rods. The stroke being given, the weight of the rods is raised by the pressure of water at the foot, derived from a fall pipe of (say) 500 ft. A valve then cuts off the fall, and the action is repeated. The application of these engines is limited, of course, to where a sufficient fall can be obtained, and then it accomplishes admirable work. Another district may be cited as worked by these machines—the Tyrolese and Bavarian salt mines, where brine is pumped up from a great depth over a hill, and so is made to run by gravitation into another district, where the wood fuel required for its evaporation is more plentiful. Another valuable apparatus is the "turbine," or horizontal water-wheel, which was first brought into a state of usefulness by M. Fourneyron. It is capable of applying water power where greater velocity is required, as in raising the mineral, instead of the slower speed required for pumping, and where, therefore, the ordinary water-wheel does not so well come into play. Instead of two to six or eight strokes a minute, these turbines get a speed on the machine of several hundred revolutions a minute. [Mr. Smyth then exhibited models of this ingenious apparatus. It is composed of two circular discs, one working within the other, fitted with curved plates of division. The water enters at the centre, diverging from it in every direction, and escapes by the curved channels from the circumference of the inner disc, and then impinges with great force upon the outer curves, forcing the machine to spin round with a velocity proportioned to the vertical column of water or height of the fall.] The turbine is a machine which might be made applicable to the direct winding of mineral, and as an extremely small machine of this kind, 2 or 3 ft. in diameter, has been found capable of raising mineral from the great depth of 220 fms. to the surface by ½ ton at a time, it would be found in many cases extremely convenient and economical. I must not omit to state plainly as regards other water-wheels that they can only be employed advantageously within certain moderate limits of velocity. It is obvious that if turned too fast there must be a loss of the power derived from the weight of the water. Thus, the proper speed for the over-shot wheel is a rate of from 6 to 9 ft. per second at the circumference. Similar reasons limit the diameter within 30 or 40 ft. If greater power be desired it is better, as I have said, to have two wheels.

We now come to steam power, which is now very largely used in mining. Formerly the double-acting engine of Bolton and Watt was the great favourite, but in its original form it is now comparatively little used. A great number of improvements on it succeeded one another, until at length what is called the Cornish engine became general. It is almost invariably single-acting—that is, the force of the steam acts only in one direction. It is, moreover, amongst the most simple of the forms in which steam can be introduced. One extremity of the beam carries a piston-rod, and the other extremity carries a main rod, which goes down the shaft. The steam is worked very expansively, and as I have said for the down stroke only. The weight to be raised, which is generally very great, is fastened to the pump-rod at the end of the beam. The steam having acted for the down-stroke, and the entrance valve being closed, a communication is formed between the top and bottom of the cylinder by lifting a valve in the steam passage, called an equilibrium valve. The pressures on the piston are thus equalised, and the weight acts to force the water up and raise the piston. Notwithstanding the excellence of the Cornish engine, curious examples of the old atmospheric engines may be seen at a very few mines. At Moira, in Leicestershire, one of Newcomen's engines of considerable size is used to lift salt water for the mineral baths. It has, however, the merit of economy where the engine is only what is called single-handed. Improved engines of a similar construction have been erected in London at some of the great water works, and may be seen in the outskirts of the metropolis, the cylinders varying in diameter from 50 to 100 in. The largest being merely for pumping on the Cornish plan, and said to be doing a "duty," taking into account the amount of coal used, of considerably more than the best of our engines are doing in Cornwall. It is not difficult to understand how this is; more attention is bestowed upon the engine, and they are not hampered with arrangements below and at the surface, and everything is kept in better order. The phrase "duty," which I have just used, refers to a system of comparison now in use, and very well understood. It is the time taken by an engine to raise 1,000,000 lbs. a foot high by the consumption of a given amount of fuel. Thus, 112 lbs. of coal is found capable of raising 50,000,000 lbs., and that would be called the "duty" of the engine by which it would be done. Thus, Bolton and Watt's engines were found to give only 18,000,000 instead of 50,000,000, while on the other hand some of the engines in Cornwall now do a duty of 90,000,000 to 100,000,000 per 112 lbs. of coal. The engine, of which there is a model in the Model Room, has done an extremely high duty. Bolton and Watt's engines, however, are still used where low pressure is preferred, and the object is to get rotary action. Another kind of high-pressure engine, with horizontal cylinders, and double action, has come into very general use for winding where a very great quantity of mineral has to be raised. Oscillating cylinders are sometimes, but not very frequently, used.

Before I proceed further I must now occupy a few minutes in speaking of the ropes and chains to be used. As regards size and strength, these vary considerably. When only manual labour is employed, and the weight lifted is, perhaps, not more than 1 cwt., a very light chain or rope would do, but when we come to steam power, and have to lift several tons at once from great depths, as in the North of England collieries and iron mines, the rope must be of extraordinary strength. The ordinary rope of three strands was used for many centuries, until a practice grew up in the deeper mines of employing flat ropes, which were found to go down and up in an even plane, and more steadily than round ropes, which are constantly twisting about. In 1830, in the Hartz mines, the question of the amount of money swallowed up in the wear and tear of ropes came under discussion, and it was proposed to make the rope of iron wire, which was then largely tried not only there, but in other parts of Europe, although at first there was great prejudice felt by the men against it. They like a good thick rope, which was very natural, for in travelling up and down these great depths men did not fancy trusting their lives to a little rope not thicker than their thumbs. They were, however, found to be consistent with great economy. They were made of three strands, with a very slight amount of twist, each strand containing a greater or less number of wires. After awhile the ropes were made round, with a hempen core, but as in use they were found to have a great deal of torsion, besides not wearing well, in consequence of their not being well looked after and cared for in passing through the shafts, and thus the wires became apt to break, so that you might often see a rope with pieces of wire projecting from it. Whenever this was seen it became high time either to condemn the rope altogether as useless, or to have the shaft examined at the places where it came into contact with the rope to prevent further damage. In collieries the ropes are carefully protected from coming into contact with the side, and they last very well. The advantages of wire are very considerable. The prime cost is not much less, but a given weight of wire-rope will support a much greater burden than a hempen rope will, so that when an engine is taxed to the utmost, and can only raise a small amount of mineral, the adoption of wire-rope would enable it to raise more. Another substance used for ropes, with a considerable advantage, is the fibre of the American aloe, used largely in France and Belgium. At the Grand Hornu some observations were made in order to test its usefulness. At one of the shafts there (No. 8), 355 metres deep, where four tubs are raised at a time, the rope is flat, made of aloe, and consists of six ropes of three strands each bound together; this did excellent work, and compared favourably in durability and efficiency with ropes made of other materials. It is usual to make the ropes taper, because the lower end has the weight to sustain all through the operation, while the upper part passes round a drum, and so has a less proportion of weight to sustain.

Chains are frequently employed, and in metalliferous mines perhaps more than anything else. They are mostly single-linked chains, and differ considerably in weight per fathom. In collieries they are largely employed, even to a depth of 450 yards, and the men are lowered to and from their work by this means. It is, however, a dangerous thing to trust men's lives to a single-linked chain, as a flaw in the iron or a bad joint might produce the most fatal consequences, and of late the practice has been very much discontinued, except, perhaps, in the Cornish mines, although it is not uncommon for tolerably new chains to break in a sudden and unexpected manner. Chains are very useful in metalliferous mines, because they may be easily twisted and turned round sharp corners, which is not the case with ropes, which, when large and strong, have a great amount of rigidity. If chains are used they ought to be made of the best charcoal iron, no matter what the cost may be, and care should be taken that the maker is a careful man, and understands the nature of his work. A good chain-maker is a person who deserves high pay, because a great amount of responsibility rests on him. Chains, also, ought to be frequently overhauled, brought up out of the pit, well washed, and every link carefully examined, which, if it were done more frequently and more systematically, would keep down the number of accidents considerably. In some districts, to obviate the danger of sudden fractures, a compound instead of a single-link chain is used, and occasionally a stub of wood is driven through every alternate link to prevent kinks when it passes round the drum.

As regards the vessel which is to convey the mineral, it is always something more or less in the shape of a barrel or bucket, more or less circular, strengthened and guarded by iron bands. The Cornish kibble is known all over the world.

There are two or three different classes of windlass. The simplest and commonest is from 3 to 4 ft. in length, and 10 or 12 in. in diameter, turned by means of a winch handle and crank. It is a matter of great importance to have these as simple as possible for the ordinary purposes of mining, as they come into play very largely for various purposes in all sorts of mining. When a shaft is of no great depth it will be found that two or three men will be able to do the work, and in the metalliferous mines a great amount of mineral has to be raised in this way, and without either horse or water power. There are places, as, for instance, in the South of Europe and South America, where water power is totally out of the question, and steam power difficult for want of water to supply the boilers, and for the same reason it may be unadvisable to employ animal labour. The use of the windlass then becomes highly important, and the question of what amount of work can be done by the labour of each man working honestly and industriously are of no little value. Experiments as to this point have been made, and principally by Messrs. Rennie and Walker, C.E., in this country, and by mechanicians of great note on the Continent, as, for instance, Gen. Moran, in France, Prof. Weisbach, in Saxony. Weisbach says that two men can raise a weight of 17 lbs. at a velocity of 2·4 ft. per second, in a pit 40 yards deep, throughout a period of eight hours, which, multiplied by 60 seconds, gives 2418 ft. lbs. raised per minute, or 8 tons 12 cwts. 86 lbs. Mr. Walker's calculation was rather different, He supposes two men employed at a windlass raising coal from a depth of 50 yards, as it is done in some districts of Yorkshire and Derbyshire to this day. One man, he says, could exert a force of 12 lbs. at a speed of 220 feet per minute; and $12 \times 220 = 2640$ foot lbs. Then, 2640×60 minutes $\times 8$ hours $\times 2$ men $\div 150$ ft. $= 7$ tons 10 cwts. 96 lbs. raised by the two men in the day. The exercise of a comparative test in this way, where you have a number of men at work, will enable you to know whether they are doing their duty, although practically they will raise nothing of the kind, because they will not be winding all the time, but be called off to perform other duties. It is something, however, to know what can be done, and you can make allowances for all fair and legitimate hindrances from the nature of the apparatus employed, and the depth from which the mineral has to be raised.

LECTURE XLV.—Although the wire-rope (said Mr. SMYTH, continuing the subject from the last lecture) has a great superiority over the ordinary hempen rope or chains, it requires to be used with great caution, for if it be turned over a barrel of two small a diameter it will not last long, and may snap very suddenly. This makes it, as a rule, inapplicable to windlass works in metalliferous mining, or, indeed, in the coal fields, where the operations are preliminary, and only conducted for the purpose of searching. A wire-rope never ought to be carried over a windlass or pulley of less than 3 ft. in diameter, and when the rope is of great strength not less than 6 ft. This, therefore, puts the employment of wire-rope with a windlass quite out of the question, as no ordinary windlass has the requisite diameter. Where, however, special arrangements are made, and a drum of 3 ft. diameter is adopted, it may be used, and I could mention examples in which wire-rope has done good service under those circumstances. For instance, in Austria, at a certain pit, 47 fms. deep, where two drums were used, the smaller of which was 32 in., experiments were made, and without going into particulars as to time of filling, &c., the amount raised by one man in seven hours was 1,269,634 foot-lbs., or 3141 per minute, by the second 1,175,411 foot-lbs., or 2902 per minute, which, reduced to the usual standard, will give results considerably in excess of those laid down by most authors, and, as you will remember, of Prof. Weisbach, who gives 2448, and Mr. Walker, the late President of the Institute of Civil Engineers, who gives 2640. Exceptionable kinds of windlass are sometimes devised to meet peculiar circumstances; as, for instance, in the extraction of the brown coal obtained in the South of France they use windlasses at which four men can work at once. Perhaps, however, there is no nation which understands the use of the windlass better than Spain, as in the mountainous parts of their mining districts they have no water power available. Indeed, water has frequently to be carried by mules up to the mines for the use of the men. The amount of work performed by the windlass there is very large, the apparatus being contrived on a large scale, so as to employ four men in turning it. There is only one other exceptional kind of windlass that I need mention, and that is where in some foreign countries in slate quarries the drum is turned into a sort of treadwheel, with steps put on the side upon which men walk. The capstan is not much used, except in particular districts. Considering the great extent to which this apparatus is used, and the great attention paid to many of its details, it is rather wonderful that no better means have been devised for the safety of the men who are lowered and drawn up in these workings. Their lives hang upon a mere thread, and, to say nothing of the rope breaking, any accident to men at the windlass would let the kibble, tub, or bucket go with a run to the bottom. In the North of England, however, they do use a clevis or spring hook, so as to prevent the possibility of accidents of this kind.

Next to the windlass and manual labour comes the horse-whim as a power for raising the mineral. Of this there are excellent examples in the Model Room, so that I need only describe its construction. When a trial shaft comes to be 10 or 12 fms. deep the miners work it by what they call "whip and derry." It is simply a pulley, placed in such a way over the shaft, on a sort of square frame, to hold the pulley wheel, over which a rope is passed, to which the horse is harnessed, it being trained to walk a proper distance on a road laid down with stone for that purpose. The inconvenience of this system is that the horse has to make a great struggle when the weight to be lifted is at the bottom, and by the same rule, in making the descent there is a constant tendency to increase the velocity, so that if the horses are not well trained and steady there is a great waste of power, and not a little danger. This plan can be recommended only for temporary sinkings while they are at no great depths. It is a question of importance which sort of pulley is the best for these small workings. They are usually about 20 in. in diameter, but I have seen pullies between 2 ft. and 3 ft. in diameter employed for horse work. The ordinary horse-whim is an apparatus based upon the wheel and axle principle, and, therefore, the power is easily calculated. It is, generally speaking, in the form of a drum, which may be from 8 to 12 ft. in diameter, built round a vertical axis, the foot of which turns on a stone or on an iron casting, and the head part of which is supported by a long span beam, resting at the extremities on inclined legs. Attached to this are an arm or arms, which must be of considerable length, generally from 30 to 36 ft., and it embraces the vertical axis close beneath the drum, which is in coal mining from 12 to 16 ft. in diameter. The ropes, passing off from opposite sides of the drum, are conducted over little guide pulleys called "jackanapes" to the sheaves set in the shaft frame overhanging the pit. These could be worked by hand labour if on a small scale, and when so treated have been found by experiment to be more effective than the windlass. Horse-whims are, however, generally employed, the hand-whim being hardly ever seen except in small experimental adventures in Cornwall. A horse, with a velocity of 2·9 ft. per second, would exert a constant force of 95 lbs. at the extremity of the axle, so that the amount of work done would be 16,539 lbs. raised 1 ft. high per minute. The difference between the results of the simpler kind of horse-whim and the windlass is measured by the fact that the former will, as I have just stated, raise 16,530 foot-lbs. per minute, as against 3000 foot-lbs. raised by the latter, showing that horse labour will produce five times the results of human labour. In the coal districts, as soon as any considerable depth is attained steam power is invariably introduced, but in Hungary, Spain, and Mexico, where it is difficult to employ water or steam power, the construction of the whim has to be guided by the greater depths to which they are applied, and the larger number of horses thereby required. In Hungary the mines are 200 fms. deep, and all the mineral has to be raised by the horse-whim, which there does extremely good service. In Spain horse and mule power holds its own against steam, as it is expensive to get weighty machinery and coal up the mountains, and the cost outweighs all other advantages. The drums sometimes are of enormous dimensions, in which case, instead of four horses (two and two, that is), they have 10 or 12 horses. The finest examples of this large kind are to be seen in Mexico, where a great number of mules are employed. In these cases one hears of mighty shafts, at which there are as many as eight sides, and a whim is placed on each face of the octagon, worked by 12 mules. In our own country horse-whims are open to the sky, and fortunately our climate is so temperate as to make that practicable, but on the Continent it is absolutely necessary to shelter them against the winter's snow and the summer's sun, and the conical roofs erected for the purpose give in many districts of Eastern Europe a peculiar character to the landscape.

In the application of both water power and horse power, great attention must be paid to the arrangement of the pulley frames, so that the friction may be as small as possible. Although water power is often obtainable within a few yards or a few fathoms, it very often has to be brought from a considerable distance. Then comes the question as to the diameter of the wheels to be employed, the size most commonly being from 30 to 40 ft. If the wheel be on a slow axle the drum shaft may be a continuation of the wheel shaft, and arranged so as to move on the circumference of the wheel at the rate of from 6 to 9 ft. per second. If the movement be either slower or more rapid than that, the full effect of the water falling on the wheel will not be obtained. If the wheel be larger an intermediate apparatus must be used for the purpose of reversing the movement, and in that case the wheel is double bucketted. This makes the wheel heavy and cumbersome, and to avoid this Mr. Smeaton, the famous engineer, contrived a system of gearing, by which the wheel could always revolve in the same direction, and the turning of the drum only be reversed. In this way a great waste of power is avoided. One axle, by means of a lever, is simply thrown out of gear, and the second thrown in, so the drum is turned in the opposite direction. Another point to be noticed with respect to wheels is the various devices which have been hit upon to regulate the respective lengths of the two ropes, which might be, for instance, in the one case 170 fms. and in the other 150 fms. To meet this the drum is often divided into two parts, one of which works by itself, while the other stands still. It is necessary to enlarge the pulley-frame considerably when greater weights have to be drawn, and powerful machinery capable of lifting a cage at one stroke 40 or 50 ft., and to place it at such a height above the ground as to prevent danger. When the velocity of the work in the shaft is greatly increased, it has been found that the rope is apt to be worn away at a rapid rate. In these days, when such great weights are raised at once, and when, with the large drums employed, the machinery is capable at one stroke of the engine of lifting the cage 40 or 50 ft., it is necessary to have the pulleys raised at a considerable height above the ground, so as to prevent danger. The pulley frames are constructed frequently, as in the Midland districts, with two uprights and two back legs, lofty enough to raise the pulley, which is generally a wheel of cast-iron, from 6 to 9 ft., but often for very rapid work from 10 to 20 ft. in diameter, to a height of from 20 to 30 ft. above the ground. The wear of the pulley wheels, when the velocity of drawing is considerable, is very great, and Messrs. Newall and Co., the well-known manufacturers of wire-rope, have introduced a mode of construction which appears less liable to the effects of wear and tear. It has a centre boss of cast-iron, and arms of cast-iron, but all the rest is of wrought-iron, and thus, being lighter, is suitable for the large diameters I have mentioned. Considering, then, how much depends upon these arrangements, the mining engineer will be careful to select such a form of pulley frame as will unite strength with simplicity, and place it where it will be the most capable of convenient application.

LECTURE XLVI.—In almost all mining districts, and in every group of mines in one and the same district, you will find that circumstances, or the taste or fancy of the managers, will lead to arrangements and conclusions more or less different with regard to the surface portions of the machinery. The forms of pulley-frames, therefore, are extremely varied. Thus, when pits are of small diameter, and it is necessary to concentrate the drawing power so as to enable the work to be carried on with a couple of bands down the same shaft, the pulley-frames must be placed with special reference to this necessity. That is to say, the head-stocks or pulley-frames are placed one on each side of the engine, taking a simple triangular form. When two bands are to be worked together, the pair of pulleys is set upon a framing of greater breadth, generally rectangular, steadied by back legs, or strutted against the engine-house. [Mr. Smyth then, in a series of drawings, exhibited different kinds of pulley-frames, and the circumstances to which they were applicable; and next proceeded to describe the different uses to which the shafts are put.] With the old-fashioned simple Bolton and Watt engines, and in metalliferous mines, the speed at which the shafts were traversed was inconsiderable, as compared with that now in daily use in the coal and iron districts; but, nevertheless, the introduction of steam led to the adoption of what are called "guides" or "conductors," in order to steady the load as it comes up the shaft. As the speed increased some such contrivance became indispensable. The system is said to have taken its rise in Saxony, and was in use there for some years before it came into vogue in England. The first to introduce it here was a Mr. Carr, of Sheffield, a colliery viewer of great repute in his day, who was the pioneer of many useful plans, now common enough, but at that time not much thought of. After some years they began to be tried by other managers, but it was not till 1824 that they were introduced into the West of England, by Mr. Holwey, of Somersetshire. Ten years afterwards they began to make their way into the North of England, and are now universally employed. They are a great advantage, not only as regards the safety of the men, where they travel up and down the shafts, but greatly facilitate the output of coal. While the bucket, skip, or kibble (German, kübel), formerly used for raising the coal, was raised without guides, the torsion of the ropes brought it repeatedly in collision with the sides of the shaft. When the down-going and up-coming kibbles met in the shaft there was great danger of collision, so that it was the rule for the engines to slacken speed while they passed, in order to lessen the risk of accident. Besides this it was impossible to make any provision for safety in case of the fracture of the ropes, no man in the shaft at such a time having the smallest chance of escaping with his life. The "guides" now usually employed are of wood, but at first a pair of wire ropes were used, stretching from the top to the bottom of the shaft, to which the kibble was attached, but this was found to be subject to much vibration,

and to make such a frightful rattle that it was most unpleasant. It is, however, an extremely simple plan, and very convenient while the shaft is in process of sinking. The next movement in advance was the employment of iron rods, fixed at the pit bottom, and screwed up to the head frame at the top, the cross bar of the cage having a ring at each end which runs upon the rods. A later application of metal was made in some of the larger collieries of the North, where bridge rails of rolled iron were attached to buntons or cross pieces, fixed across the pit at intervals. In the greater number of collieries, however, the guides are made of Memel pine, generally either 4 in. by 3, or 5 in. by 4 in. thick. These rails are extremely firm and durable, and have the preference at pits where an amazing amount of work is done, and the drawing accomplished with unusual ease and rapidity.

The subject of the cages, by means of which the mineral is drawn to the surface, and which travel up and down the guides, follows naturally what I have just said. Formerly the mineral was raised from the bottom in simple buckets hooped with iron. Occasionally, as, for instance, in Belgium, these were made of large size, holding 1 or 1½ ton, and simply travelled up and down the shaft. They were lowered until opposite the level, and then were filled and drawn up, when, on arriving at the surface, the coals were "tipped" out on the pit bank, increasing, however, by that treatment the proportion of slack. All these old methods are now things of the past, or only used temporarily, and have given way to what are called cages. These are invariably constructed of iron, and they are so arranged that instead of kibbles the wagons in which the coal is conveyed along the levels are run into the cage, and drawn up laden. On reaching the surface the wagons are pushed off, and drawn to the spot at which the coals are to be dispatched to market, or stacked, their place in the cage being filled with empty wagons, which descend, and are changed for full ones. The cages being conducted by guides bring up at the surface opposite a platform on which rails are laid down to the very edge, and meet those on the floor of the cage, so that the wagons can run in and out with great facility. There is a good deal of variety in cages, the differences in many cases arising from the magnitude of the work to be done being seldom alike. Thus, they are either single or double the latter carrying two wagons side by side, or they may have two decks or stages, one above the other, and so carry four wagons. Indeed, in some of the Belgian collieries they have six deckers, intended to carry six pairs of wagons over each other. Some admirable specimens of these were exhibited at the Paris Exhibition, and at that of 1862 in Hyde Park. These large cages have been long used at the Grand Hornu Collieries, near Mons. The mode of loading this cage is very ingenious, and enables the work to be accomplished in a most expeditious manner. At the bottom of the shaft a level branches off on each side, and at a short distance from the mouth of each level a small winze is sunk, of just sufficient dimensions to allow of a tub of coal being let down into a small passage which communicates with the shaft at a lower point than the level. The object of this is to allow of the loading and unloading of two of the decks of the cage, to be carried on simultaneously on each side of the shaft, the first and third deck being filled on one side, and the second and fourth on the other. The tubs are let down from the levels into the lower passages by means of a pulley and rope. One great point in regard to rapidity in raising the mineral is to see to discipline amongst the men, as attention to this may in some cases double the quantity of mineral raised in a given time. Occasionally the output has been increased from 200 or 300 tons a day, to 400, 500, or 600 tons in the same time, and with no larger a number of men, solely in consequence of attending to this point. It is only by a proper regard being paid to this matter that it is possible at some collieries to raise so large a quantity as 1000 tons in a day. The arrangement at the Grand Hornu works remarkably well, and from 1200 to 1300 tons have been raised from a depth of 500 yards in 12 hours. Cages of this magnitude are extremely heavy. They are built of iron for the sake of strength, and often weigh as much as 1½, 2, or 3 tons, and the use of steel as combining strength and lightness has lately been tried with success. The slide parts of the cage, of thin wrought-iron, which loosely fit to three sides of the wooden conductor, are applied both at the upper and lower bar of the framing, and are a little bell-mouthed upward and downward to allow them to slip more freely over inequalities. In order, also, to keep the tubs from shifting during their transit, a simply contrived latch is always applied either on the floor of the cage or at the ends of a rod passing through its upper bar; and when the weight reaches the surface, duly signalled on its approach by a bell ringing in the engine-house, and by some visible mark attached to the rope, the cage is lifted with its floor a little above the plane of the bank at which it is intended to rest, and then allowed to drop on to the *keeps*. These latter are the heads of an arrangement of counter-balanced levers, which offer no obstacle to the ascent of the cage, but, by a simple movement of the hand or foot of the lander, are made to protude and catch it in its descent. The moment that, at a lively pit-mouth, the cage bottom touches the keeps, the landers have already got hold of the full tubs to pull them on to *terra firma*, or are forcing them out with the empty ones which they are pushing in to take their places. On the iron plates with which the staging about the pit top is floored, the wagons are hauled off, up goes the cage with a jerk a few feet, and anon plunges down again into the gloom, whilst the men are rushing forward with the empty tubs prepared for the fellow-cage, which in a few seconds flies up by the other side of the pit.

There is another point to be looked at of great importance in winding from deep shafts. As the full cages are drawn up the empty ones descend, and there will be some place in the shaft where the former will be balanced by the latter, but at all other points there will be an increasing momentum arising from over-balancing. This is easily ascertained by a simple equation. It is necessary, therefore, in deep pits to have some drag or counterpoise to prevent the rope running off at too high a velocity in the lower part of the descent; contrived, however, so as to give the fullest leverage to the engine when the loaded cage starts from the bottom of the pit. Flat ropes were largely used at one time for this purpose, as they cased the engine by coiling one lap over the other, and thus formed a counterbalance, but of late years this has been better done by round wire-ropes on conical drums, in which the small end may run up from 16 to 20 ft., and with care to prevent slipping these drums are a great improvement.

A very useful class of apparatus has occupied much of the attention of mining engineers and inventors, with a view to prevent those terrible accidents which now and then happen in the shafts by the breaking of the ropes. They are called safety-cages, safety-clutches, or, as in France, parachutes. When the winding is done at a moderate rate, effective service is done by them, but it is a matter of much debate amongst the viewers and managers whether it is not better to do without them, and trust to a careful supervision of the whole machinery, coupled with the selection of a careful man to work the engines, and having the tackle all of the best kind. Some of these contrivances are extremely ingenious. They may be divided into two classes, in one of which two levers are brought into action at the moment of the fracture of the rope, which fly out, clutch the guides, and so hold the cage; and in the other they stick into instead of clutching the guides, with the same result. In Lancashire the safety clutch, invented by Mr. Owen, is much used, and has done much service. In the great French mines, at Anzin, they use an apparatus of this kind, which is said to have saved 70 or 80 lives, and is, therefore, entitled to be spoken of with respect. [Mr. Smyth then exhibited a number of working models of various kinds of safety-cages, remarking, however, on the general subject that with the rapid winding of the present day (of which he gave as an example the fact that at Monkwearmouth, in the North of England, they wound at a speed of 280 fms. in a minute), there was a constant tendency in the rope occasionally to surge or slacken for a moment, and thus not to exercise the same tension all through, by which means the hold-fasts might let go the safety-levers when they were not required, and the cage be brought to a stand in the middle of the shaft. Amongst other admirable ones is that in use at Seaton Delaval, where the winding speed is not exceeded by any colliery in the world, which may turn out to be free from some of the practical objections to these apparatus, but it is still on its trial. In spite of every precaution, there would still be breakages of the rope, and a satisfactory arrangement to meet such accidents would be an invaluable boon.]

GEOLOGICAL SOCIETY OF LONDON.

April 14: Prof. HUXLEY, LL.D., F.R.S., (President), in the chair.

Captain William Price, M.P., of Tibberton Court, near Gloucester; Sir David Wedderburn, Bart., M.P., of 17, Pall Mall; A Rogers, Esq. (Bombay Civil Service), Heath End House, Hampstead; W. E. Koch, Esq., 31, Oxford Square, Hyde Park; and the Rev. James Kernahan, M.A., Ph.D. (Rostock), F.R.S.L., F.E.S., 50, Greenwood Road, Dalston, were elected Fellows of the Society.

The following communications were read:—

"On the Coal-Mines at Kaianoma, in the Island of Yezo," by F. O. Adams, Hon. Secretary of Legation in Japan: communicated by the Secretary of State for Foreign Affairs.

The writer states that the works at Kaianoma have made considerable progress since they were reported upon by Mr. Mitford last year. There are four seams of coal, each about 7 ft. thick, from 50 feet to 100 ft. apart. A tunnel has been driven through one of the seams for a distance of between 150 and 250 ft. and at an elevation of 430 ft. above the sea. From this the coal obtained is carried down to the shore on the backs of men, mules, and ponies. The writer adds that there is abundance of coal "of the cannel description."

"On a peculiarity of the Brendon-Hills Spathose Ore Veins," by M. Morgans, Bristol: communicated by Warington W. Smyth, F.R.S., F.G.S.

The author described the Brendon Hills as consisting of a Devonian slate, dipping S. by E. and N. by W. on the two sides of the axis of elevation. The cleavage laminæ dip S. by W. at an angle of 80°, and the cleavage strike forms only a slight angle with that of the beds, which, however, is sometimes irregular. Veins of spathose iron ore, very rich in manganese, occur in the slate; and the general dip of these appears to coincide with that of the cleavage planes. The veins consists of thin "tracks" of softened clay-slate and quartz, with larger or smaller pockets of productive ore. These metalliferous portions do not descend parallel to the line of their dip, but slope more or less, usually to the west. The author stated that the veins have been segregated from the adjoining clay-slate, the unproductive portions of them occurring where the conterminous strata were not impregnated with sufficient ferruginous matter to produce a lode of iron ore; the slope of each productive part, called "end slant" by the author, is determined by the line of intersection of the plane of the vein with the boundaries of the ferruginous portions of the beds.

Mr. Etheridge thought that the great iron lodes of this district lay in the great faults which traverse the country, and in which there had been considerable downthrow to the north. In most cases in the Bristol district the lodes seem to have been formed at the bottom of the sea during the New Red Sandstone period by infiltration of salts of iron into the faults.

"On the Salt Mines of St. Domingo," by F. Ruschhaupt: communicated by Sir R. I. Murchison, Bart., V.P.G.S.

The author described the Cerro de Sal, or Salt Mountain of St. Domingo, which extends about 3 leagues in length, and consists, according to the author, of rocks "of the Red Sandstone class," and where the chief visible deposits of salt occur are principally gypsum-schists, sometimes very argillaceous. The salt is generally surrounded by an ash-like mass, consisting of gypsum and clay. The author compared the gypsum beds with those of the Keuper. The beds are are thrown into a perpendicular position, and the same change is observed for miles in the Savanas. An immense body of salt, 250 to 300 ft. broad, is exposed upon the north side of the mountain. The salt is very white and pure, and might easily be conveyed to the port of Barahona, about 18 miles distant.

Sir R. I. Murchison had been at a loss to understand how such beds of salt could co-exist with shells of recent species in St. Domingo. The question seemed, however, to have been solved by the Geological Survey of many of the West Indian Islands, which had determined that all these deposits were of Miocene age. In the majority of the islands there were no rocks so old as the Cretaceous, and he, therefore suspected, that there was an error on the part of the author in regarding the beds of St. Domingo as belonging to the Trias.

Prof. Ramsay thought it was more remarkable that any salt deposits of the New Red Sandstone should exist than that there should be so many of Miocene age. There was not much probability of great salt deposits of more recent date, as there had hardly been sufficient time for their formation, though in the Great Salt Lake and elsewhere such deposits were now forming. The reason why such old deposits of salt had been preserved appeared to be that the salt had been hermetically sealed up in impermeable marl as soon as the part of the salt which lay near the outcrop of the beds had been dissolved away.

Mr. Etheridge was satisfied that the shells from St. Domingo which came with the salt are of Miocene age. In other West India Islands gypsum of Miocene age occurred, and pseudomorphs of salt. He recommended Mr. Sawkins's work on the Geology of the West Indies to the attention of geologists.

"A description of the 'Broads' of East Norfolk, showing their origin, position, and formation in the Valleys of the Rivers Bure, Yare, and Waveney," by R. B. Grantham, C.E., F.G.S.

"On a peculiar instance of Intraglacial Erosion near Norwich," by Searles Wood, Jun., F.G.S., and F. W. Harmer.

"On the Lignite Mines of Podnernuovo, near Volterra," by E. J. Beor, F.G.S.

The author states that the deposit of Lignite at Podnernuovo, near Volterra, is of Lacustrine origin, and consists of two parallel strata of compact coal about 2½ metres (=8 ft. 4 in.) in thickness, separated by a thin stratum of marl, with marsh-shells. The lower coal bed lies on a bed of marl with marsh shells, and the upper bed is covered by a marine formation belonging to the Upper Miocene. The lignite comes to the surface near the Alberese, where it extends for a considerable distance. Some shifts occur bringing the upper bed down nearly to the level of the lower one; the inclination of the beds diminishes gradually, and the intervening stratum of marl decreases in thickness, and probably at last thins out altogether. The coal in the upper bed is better than that in the lower one. The author remarks that this lignite deposit differs from those of the neighbouring valleys in being purely of marsh origin, while they are Estuarine.

On Wednesday the following communications will be read:—1. "On the Geology and Mineralogy of Hastings County, Canada West," by T. C. Wallbridge: communicated by Dr. Percy.—2. "On the distribution of Flint Implements in the Drift, with reference to some recent discoveries in Norfolk and Suffolk," by J. W. Flower, F.G.S.—3. "On a raised Beach at Portland Bill, by W. Whitaker.

IRON AND STEEL.

The progress of competition between England and foreign countries, especially in the iron and steel trades, renders it each year more desirable that our manufacturers should possess a complete knowledge of the particular advantages which the products of each country possess, and of the steps taken to secure the recognition of whatever good qualities in them may be most prominent. For conveying information of this nature, Mr. Sandberg's translation of the volume* containing Mr. Knut Styffe's report of the investigations undertaken at the instance of the committee appointed by His Majesty the King of Sweden, and consisting of Messrs. Ekman, Styffe, and Grill, to examine railway plant of home manufacture, and determine the fitness of Swedish iron for such materials, is of the greatest value. As the qualities of iron and steel are dependent to a great extent upon the treatment which the metal has received whilst undergoing the processes of welding and rolling, it follows that the greater the number of operations though which the finished article has passed the more difficult does it become to determine whether certain of the qualities which it exhibits are derived from the raw material originally employed, or whether they have been developed by the manipulation to which the metal has been subjected. As these circumstances should not be forgotten in pronouncing an opinion on a new product manufactured by inexperienced workmen, the committee considered that an enquiry into the qualities exhibited by different kinds of iron and steel, as they occur in the form of rolled or of forged bars, would be of very considerable importance in determining the employment of these materials for different kinds of railway plant; and, in certain cases, would be more profitable than an examination of the finished objects manufactured of such materials. From this statement the task which the committee undertook will be thoroughly understood, whilst the manner in which it was carried out cannot fail to give the utmost satisfaction.

The first object was to examine the different elastic properties of iron and steel, and every care has been taken to give the utmost value to the experiments by furnishing the most exact details as to the testing machine used, the mode of conducting the several experiments, and the results obtained. As to the details of the testing machine, and the manner of conducting the experiments, the book itself must be consulted; but it may be stated that the results at which the experimenters have arrived from their experiments on tension performed at the ordinary temperature confirm to a great extent those of other observers. They find that the limit of elasticity, in the sense in which that expression is generally understood, or as it is defined by Wertheim and other observes, cannot serve as a guide to the determination of the different elastic qualities of metals, inasmuch as it does not admit of being determined with the requisite degree of accuracy. On the contrary, an easily-determined measure of the limit at which any permanent elongation of practical value first occurs in iron and steel may be obtained if the limit of elasticity be defined, as that load by which when it has been operating by successive small increments (the iron or steel bar being gradually extended by successive loads, at first so small as to occasion no perceptible permanent elongation, but gradually increased, and always allowed to operate for as many minutes as each additional weight is per cent. of the entire load), there is produced an increase in the permanent elongation which bears a ratio to the length of the bar equal, or approximating most nearly to, 0·01 of the ratio which the increment of weight bears to the total load. It seems that the amount of permanent elongation produced by stretching iron and steel is dependent not only on the chemical constitution of the material, the manipulation to which it has been subjected, and the regularity of its section, but also on the method by which the traction is effected. These elongations generally increase more rapidly than the excess of the loads above those at the limit of elastricity; but it may be assumed that they are approximately proportional to this excess.

The mechanical treatment to which the material has been submitted, and the temperature to which it has been exposed either during working or subsequently, is found to have a considerable effect in both iron and steel upon the limit of elasticity, the absolute strength (*absoluta styrka*=tensile strength), and the extensibility. By cold hammering, cold rolling, and other forms of mechanical treatment, applied at a low temperature, both the limit of elasticity and the absolute strength are increased, whilst by the same treatment the extensibility diminished. In these respects heating produces an opposite effect. When the proportion of carbon in iron or steel is increased, whilst other conditions remain the same, the limit of elasticity as well as the absolute strength, is to a certain extent increased, but the extensibility, on the contrary, is diminished. The absolute strength, which in good soft iron may be estimated in round numbers at 48,034 lbs., or 21·44 tons per square inch, seems to attain its maximum in steel containing about 1·2 per cent. of carbon, and is then in good cast-steel or Bessemer steel about 137,240 lbs., or 61·26 tons per square inch.

The observations on the influence of phosphorus and slag on iron deserve, as Dr. Percy remarks, careful consideration; and the same may be said with regard to the doctrine propounded as to the beneficial influence of the diffusion of slag through iron containing phosphorus in sensible quantity, in order to counteract its injurious effects. Mr. Styffe finds that a small proportion of phosphorus in iron generally raises the limit of elasticity and the absolute strength, and, therefore, also the hardness of the metal; but, at the same time, it diminishes its extensibility, provided that the iron during its manufacture has been so much drawn out that on slow rupture it exhibits a fibrous fracture. By admixture, however, of slag (which always makes the iron unsound, and difficult to be re-formed when heated, but which facilitates the development of a fibrous structure) an iron containing 0·25 per cent. of phosphorus seems capable of acquiring nearly the same extensibility as an iron which contains only traces of phosphorus. The presence of slag also seems to oppose the tendency of the iron to become, when strongly heated, crystalline, and therefore cold-short. With regard to the influence of phosphorus in certain proportions upon the tenacity of iron, the results obtained agree pretty closely with those of Karsten. The tensile strength of iron is found not to be sensibly impaired by the presence of even 0·2 or 0,3 per cent. of phosphorus, provided the metal has not been strongly heated after having undergone the operation of rolling or extension by other manipulation. But, what is important, the extensibility of iron is lessened by the phosphorus. With regard to the injurious influence of phosphorus on steel, Mr. Styffe knows no authenticated instance in which the proportion of phosphorus has been higher than 0·04 per cent. in what has been considered a good steel, but he considers that with regard to the influence of phosphorus on steel our knowledge is at present more imperfect than it is with reference to the effect of that element on iron.

With reference to the effects of hardening and tempering, it is found that by heating and sudden cooling the limit of elasticity is raised, whilst the extensibility is diminished not only in steel but also in iron. The absolute strength is likewise increased by hardening, if this be performed in a manner adapted to the quality of the material. Hardening in water, without subsequent moderate heating, generally diminishes the strength of hard steel to a very considerable extent, whilst hardening in oil does not occasion this inconvenience, provided that the heat previous to hardening has not been too high. It has also been found that the elastic force which iron and steel develope on stretching is not always equally powerful in the same material, but is dependent on the manner in which the metal has been previously treated. Thus, by such mechanical operations as stretching, hammering, &c., the elasticity may be diminished, whilst by a moderate heat, or, still better, by a glowing heat, it may be increased. Moreover, it does not vary to any great extent for different kinds of steel, nor for steel and good iron; but it generally decreases with the specific gravity. The measure of this force, or the modulus of elasticity, may be estimated in round numbers at 30,879,000 lbs. per square inch for rolled or forged bars, having a specific gravity of about 7·80, and containing only a trace of phosphorus; but for iron bars, in which the material is very cold-short, or contains a considerable proportion of slag, it is only about 27,458,000 lbs. per square inch. On the contrary, in Bessemer iron, with a specific gravity of 7·88, the modulus of elasticity may rise to about 34,310,000 lbs. per square inch.

Applying the results obtained to the determination of the relative values of iron and steel, and different kinds thereof for different purposes, it is explained that in consequence of the considerably greater strength of steel, and of the much higher position of its limit of elasticity, the dimensions of articles manufactured of this material may be smaller than when iron is employed, and, therefore, the use of steel offers considerable advantage over iron for such objects as require to be made as light as possible, such as the motion parts of machinery, vessels, all rolling stock, &c. Steel—and especially cast-steel, which unites with hardness and strength a high degree of homogeneity—should be preferred to iron for all purposes which require not only strength but power of resistance to wear, such as rails, axles and tyres for railway carriages, piston-rods, and other parts of machinery: the value of steel for such purposes has long been recognised, and the only great obstacle to its extensive employment hitherto has been the high price of cast-steel. This obstacle has, however, been to a great extent removed by the discovery of the Bessemer process, and by the improvements which within the last few years have been introduced into the manufacture. A certain degree of extensibility is indispensable not only in the material of those articles previously referred to, but in most other parts of machinery or of buildings which may be supposed to allow without fracture any slight alteration of form that may arise from irregularity in the construction, or from any extraordinary strain. The importance of this should by no means be overlooked in those structures which consist of several separately wrought pieces, such as an iron bridge or a boiler, for these can never be so constructed that the strain is from the beginning evenly distributed throughout. If, then, the component parts are not sufficiently extensible they may be broken successively long before reaching the strain for which the bridge or the boiler was calculated. In such a case the elastic elongation which the separate parts could assume is commonly an insufficient guide.

Some authors have asserted that steel, in consequence of its great strength, is indeed well adapted for any purpose in which it is exposed to strains that operate only gradually, but that it is, on the contrary, quite unfit for any purpose in which the material is exposed to sudden shocks or blows. In order to determine how far this assertion is true, Mr. Styffe examined the effect of a sudden shock applied to a bar in the direction of its length when the bar is steadily fixed at one end; and also when acting from above in a vertical direction on the middle of the bar, the free ends of which rest on two solid supports. The mechanical force necessary to break or strain different bars when acting gradually is not strictly the same as that required to break or strain the same bars when acting suddenly. As the tougher material may yield to a greater extent when affected by a shock, it may thus longer resist the effect, and may sustain a more violent shock than if it were twice as strong, but had only one-fourth the extensibility, although the amount of its power of resistance would be greater in the latter case; hence a bar of iron can, by assuming a great permanent change of form, sustain a shock which would break a hard steel bar of the same dimensions, although the latter is able to carry a greater load if acting gradually. In those articles which, when subjected to very severe shocks, may, without any great danger, assume a considerable change of form, but whose fracture would entail important consequences (such as armour-plate), the material must necessarily possess great toughness. In other cases, as in certain parts of machinery, the inconvenience attending a change of form may be as great as that consequent upon rupture, if not, indeed, greater; and, therefore, in the choice of the material for such purposes strength must be considered as of first importance, and extensibility as secondary. In determining the degree of hardness of steel best adapted to special purposes, regard must be had to the circumstances under which the articles will be employed, and to their method of manufacture. There are several qualities beyond those brought under notice in experiments on tension which determine the value of an iron and its application to different purposes. In the choice of a material for many parts of machinery (certain kinds of smiths' work, &c.) the strength of the iron is of comparatively small importance—the more so as this may not unfrequently be raised by suitable mechanical treatment. But in general the points which demand first attention are the soundness of the iron, and its freedom, as far as possible, from prejudicial impurities—especially slag, sulphur, and phosphorus—so that the iron may readily be worked hot without cracking, and may not become brittle on cooling. For many such purposes a pure iron carefully refined in the charcoal hearth must still retain the position it has justly acquired, and will withstand competition even against the best puddled iron.

From the experiments on tension at widely different temperatures, it is found that the absolute strength of iron and steel is not diminished by cold, but that even at the lowest temperature which ever occurs in Sweden it is at least as great as at the ordinary temperature (about 60° Fahr.) At temperatures between 212° and 392° Fahr. the absolute strength of steel is nearly the same as at the ordinary temperature; but in soft iron it is always greater. Neither in steel nor in iron is the extensibility less in severe cold than at the ordinary temperature; but at from 266° to 320° Fahr. it is generally diminished, not, indeed, to any great extent in steel, but considerably in iron. The limit of elasticity in both steel and iron lies higher in severe cold, but at about 284° Fahr. it is lower at least in iron than at the ordinary temperature. The modulus of elasticity in both steel and iron is increased on reduction of temperature, and diminished on elevation of temperature, but that these variations never exceed 0·05 per cent. for a change of temperature of 1° centigrade (1·8° Fahr.), and, therefore, such variations, at least for ordinary purposes, are of no special importance. From the experiments on flexion it appears that iron sustains at low temperatures a smaller load than at the ordinary temperature before it obtains any perceptible permanent deflection. The modulus of elasticity for steel and iron on flexion may, for practical purposes, and without committing any considerable error, be generally assumed equal to that on traction. It is diminished by permanent deflection, but may be restored by heating, especially if raised to a red heat. By hardening steel, its modulus of elasticity is diminished; but this diminution has not, in any of the hardened bars examined, amounted to more than about 3 per cent. The elastic force of steel and iron on flexion, as on traction, is increased on reduction of temperature, and diminished on elevation of temperature. The amount of this increase or decrease for a change of temperature equal to 1° centigrade (1·8° Fahr.), does not, however, in general amount to more than 0·03, and apparently never rises to 0·05 per cent.,

* "The Elasticity, Extensibility, and Tensile Strength of Iron and Steel." By KNUT STYFFE. Translated from the Swedish by Christer P. Sandberg. With Preface by Dr. Percy. London: John Murray, Albemarle-street.

That much remains to be done in the direction of experimental research before such problems as the relation between tensile strength and composition, previous mechanical treatment, and temperature can be satisfactorily solved will be generally acknowledged, and hence it is that so much interest attaches to the record of such investigations as those undertaken for the Swedish Government. The present volume affords an almost inexhaustible amount of material for thought, and goes far to prove how little is really known upon these subjects. The percentage of phosphorus and carbon is not in all cases given, but from the elaborate tables which are appended to the work, showing the results of experiments on the tensile strength of steel and iron at 60° Fahr., the subjoined is extracted:—

Description of Iron or Steel. (Samples marked * were square, others round.)	Carbon per cent.	Phosphorus per cent.	Limit of elasticity.	Breaking weight.	Elon. by rupt.
Tilted Bessemer steel, Högbo	1·14	0·018	85,431	56·94	2·8
Rolled Bessemer steel, Carlsdal*	0·38	0·023	34,990	28·88	16·7
Rolled Uchatius steel, Wikmansbyttan	1·16	0·011	71,707	62·43	4·6
Tilted Krupp steel, one crown	0·62	0·022	50,092	38·13	6·4
ditto two crowns	0·61	0·030	55,925	36·85	5·5
Tilted Bessemer iron, Högbo	0·33	—	52,151	31·85	5·5
Rolled puddled iron, Lowmoor	0·21	0·068	36,025	26·31	20·5
ditto Dudley	0·09	0·346	28,134	18·63	6·6
Ditto, Middlesbro', marked "Cleveland"	0·07	0·295	—	32·38	18·7
Rolled iron, Motala Works (Sweden)	0·20	0·020	29,506	23·49	17·3
Ditto, Aryd Smaland (charcoal hearth)	0·18	0·264	40,485	28·33	8·2
Ditto, Hallstahammar (ditto)	0·07	—	27,104	22·73	16·7
Ditto, Lesjöforss (Lancashire hearth)	0·07	0·022	24,360	20·09	22·0
Planed and rolled sample from—					
Outside of Low Moor engine tyre*	—	0·158	34,993	23·92	12·9
Head of Cwm Avon rail*	—	0·240	—	21·75	6·6
Stem of Cwm Avon rail	—	0·222	—	19·75	3·4

The amount of carbon and phosphorus is stated, according to determinations made at the School of Mines, at Fahlun; the column "limit of elasticity" shows the load in pounds per square inch at the limit of elasticity, and the "breaking weight" means the breaking weight in tons per square inch of the original mean area. The observations which might be made upon these figures, especially considered in connection with those which accompany them in the original tables, would be almost innumerable, but space being necessarily limited, the reader of the book must be left to draw conclusions for himself, or rather to determine when the conclusions arrived at by the authors appear open to question. With a view to make the work complete, a very valuable appendix has been added by Mr. Sandberg, giving the details and results of his experiments on iron exposed to sudden shocks at different temperatures, the elasticity of the supports remaining constant, or nearly so. He observes that in considering whether steel should be substituted for iron certain objections have long been brought forward, especially in those countries which suffer from a severe climate, such, for instance, as the Scandinavian peninsula, Russia, Canada, and the northern part of America. On this point the author has, by his elaborate experiments, arrived at certain remarkable results, which run directly counter to the general belief—results which show, indeed, that iron and steel are, if anything, actually stronger when exposed to severe cold than at ordinary temperatures. The author, however, cannot deny that both iron and steel employed as railway material, and, consequently, exposed to sudden concussions, break more frequently during extreme cold than at ordinary temperatures, but he explains this fact by referring to the diminished elasticity of the supports upon which the metal rests; he also admits, but attributes to the same cause, that it is just when exposed to the most intense cold that fracture most commonly occurs. Referring to this portion of the experiments, Mr. Fairbairn remarks that the general objection to the use of steel as a substitute for iron is the want of uniformity in the manufacture. If steel could be depended upon in regard to strength, elasticity, &c., it would shortly take the place of iron, at a considerably increased price.

In order to investigate the cause why iron in such cases as those cited is disposed to break more readily when subjected to blows during extreme cold than at ordinary temperatures, and in order to determine how far this is really due to diminished elasticity of the supports, and how far to increased brittleness in the metal itself, Mr. Sandberg proposed to the Royal Administration of Government Railways the execution of some experiments on a large scale, and in a simple but practical manner. Iron rails were supported on blocks of granite, which in their turn rested on a solid granite rock, and the rails having been broken into halves were then tested by the fall of a heavy ball—one-half of each rail being examined in winter at 10° Fahr., and the other half in summer at 84° Fahr. These experiments tend to contradict some of Mr. Styffe's conclusions, the results of Mr. Sandberg's experiments showing that for such iron as is usually employed for rails in the three principal rail-making countries (Wales, France, and Belgium) the breaking strain, as tested by sudden blows or shocks, is considerably influenced by cold, such iron exhibiting at 10° Fahr. only from one-third to one-fourth of the strength which it possesses at 84° Fahr. They further prove that the ductility and flexibility of such iron is also much affected by cold, rails broken at 10° Fahr. showing on an average a permanent deflection of less than 1 inch, whilst the other halves of the same rails broken at 84° Fahr. showed a set of more than 4 in. before fracture. Another and somewhat remarkable result shown by Mr. Sandberg's experiments is that change of temperature affects different rails in a very different degree—at summer heat the strength of the Aberdare rails was 20 per cent. greater than that of the Creusot rails, but in winter the latter were 30 per cent. stronger than the former. The French rails appear to vary less in strength through change of temperature than either English or Belgian; but the variation in French, English, and Belgian rails is so excessively inconstant that it would be dangerous to attempt any closer approximation than that which Mr. Sandberg makes.

The work from which the vast amount of practically valuable information here given has been gathered is one of the most important additions to the literature relating to strength of materials which has appeared for some time, and one which may be profitably studied both by the manufacturers of iron and steel and by those who are engaged in their employment for construction purposes. No pains have been spared to render the experiments useful nor to place the results before the English readers in the best possible manner.

PRACTICAL TREATISE ON METALLURGY.

The second volume of Messrs. Crookes and Röhrig's translation of Kerl's Metallurgy has now been issued, embracing the Metallurgy of Copper and Iron. It is very truly remarked that iron is not only more useful than the other metals, but there is also a great difference in the mode of its production. Whilst other metals are met with in commerce nearly chemically pure, iron is metallurgically produced in a combined state, forming three distinct varieties—indeed, it may almost be said three metals—so widely do their properties differ. Each variety of iron may be produced in various ways, and although more study has been devoted to iron and its production than to any other metal, there is still great scope for improvement. There is also a great difference between the smelting of iron and the smelting of other metals. In most smelting operations the crude metal only is usually produced, whilst in the smelting of iron the producer is almost always a manufacturer as well; he fabricates rails, tyres, plates, &c., and, in fact, production and manufacture are so closely allied as to be inseparable. It is explained that the manufacture of the three varieties of iron must be conducted with reference to the purpose for which the product is intended—this may be called the chemical section of the iron manufacture, or metallurgy proper, whilst the further treatment of the iron, such as rolling rails, &c., forms the mechanical part. In the present volume* the mechanical portion of the subject is but briefly alluded to; on the other hand, the production of the different kinds of cast and wrought iron and steel are very fully described. In treating of copper, considerable prominence has been given to the question of the copper-smoke nuisance.

The principal ores of copper having been described in the first chapter, a synopsis of processes for the extraction of copper from its ores is given. The extraction is mostly effected in a dry way, either by a smelting process in cupola furnaces (German process), or by treating the ores in the reverberatory furnaces (English process). The wet way is employed when the ores are too poor for profitable smelting. The conditions upon which the employment of the German or English process depends are carefully enumerated. The modes in which the several kinds and classes of ore are treated by the wet and the dry processes are described, and the details of the several processes are then given. The various processes of roasting the ores, smelting the roasted ores and roasting the raw matt, concentration, smelting of the roasted raw matt, roasting the concentrated matt, smelting the roasted concentrated matt for the production of black copper, refining the black copper, refining the black copper in small hearths, toughening, poling, &c., are in turn explained; and illustrations are then given of the German method employed in smelting copper ores free from lead, silver, and gold, and of smelting argentiferous and auriferous copper ores by the German method. After this the copper-smoke question, and many other processes beside those above mentioned are referred to, the description in each case being ample for all practical purposes. The metallurgy of copper not having hitherto been so fully referred to as that of iron and steel, we shall take another opportunity to refer to this portion of the work in a distinct article.

After explaining the classification of iron, and the kinds and properties of pigs, the extent to which the qualities of pig-iron are modified by the various foreign substances with which it is frequently contaminated, commencing with silicon, Prof. Kerl remarks that good grey foundry pig-iron may contain as much as 2 per cent. of silicon; if containing a larger amount it is harder and less strong, but it may be improved by re-melting, when part of the silicon will be separated; such iron, containing an excess of silicon, is fine-grained, of light colour, has but little lustre, and solidifies quickly. Forge pig suffers more loss of iron by scorification the more silicon it contains; it may, nevertheless, be more advantageous to produce pig-iron rich in silicon and poor in sulphur, when treating impure ores at a high temperature, than by employing a low temperature to produce iron poorer in silicon and richer in sulphur, as silicon may be more perfectly separated than sulphur. The state of combination of the silicon essentially influences the behaviour of the iron at its conversion into malleable iron. Lohage suggests that grey forge iron should contain at least 2 per cent. of silicon in order to form a slag which shall thus preserve the iron from further oxidation, and as the silicon first oxidises time is allowed for the separation of sulphur and phosphorus; forge iron containing above 1·5 per cent. of silicon is not usually desirable. Bessemer considers a certain amount of silicon necessary in the steel produced by his process in order to obtain solid castings; but Tunner, in his account of the London International Exhibition of 1862, questions the accuracy of this supposition. Schafhutäl suggests that a certain quantity of silicon is required for the formation of steel, whilst Jullien considers the least amount of silicon to be detrimental to the quality of steel. These contradictory views necessitate further investigation. According to Karsten, all good wrought-iron contains at least 0·05 per cent. of silicon, which amount may rise even to 0·1 per cent. without much prejudice to the strength of the iron; this, however, will not be the case if the iron contains 0·37 per cent. of silicon. Wrought-iron containing a larger amount of silicon renders steel red-short.

The effect of sulphur upon the metal it contaminates is likewise very fully referred to. As an amount of sulphur is more or less prejudicial to the applicability of iron to almost any purpose, the sulphur must be removed as much as possible. The removal of the sulphur by hand-sorting the ores is first aimed at, and afterwards by such chemical operations as roasting, weathering, and lixiviation; but, as these remedies are not sufficiently effective, other methods must be applied at the smelting process. Lime is added to form sulphide of calcium, which dissolves other metallic sulphides, and sends them into the slag. Manganesiferous fluxes are used; the manganese combines with sulphur and the sulphide of manganese formed partly separates from the liquid pig-iron, and partly enters the slag, together with other metallic sulphides. Part of the sulphide of manganese also enters the ferriferous bears (finished pigs?) sometimes in a crystallised state. These fluxes at the same time facilitate the formation of white iron. Mixing superheated steam with the blast has proved effectual in some cases, but it has the disadvantage of cooling the furnace. Tilghman recommends the introduction of common salt with the blast, in order to form volatile chloride of sulphur, but this reagent is too volatile and too expensive. Electrolysis has been proposed by Winkler—upon conducting the electric current into the liquid iron in the hearth of the blast-furnace, iron and manganese will form the positive, and pure carbon the negative electrode, and sulphur, phosphorus, and silicon will be separated—but the practical application of this method is involved in many difficulties, and, consequently, does not give the expected results. A small amount of sulphur (0·4 per cent.) renders grey iron thinly liquid, light grey or mottled, and more compact sulphurous iron ores are sometimes, therefore, intentionally employed when aiming at the production of solid castings; on the other hand, the presence of phosphorus is injurious. The amount of sulphur in grey foundry pig seldom exceeds 0·5 per cent., and is usually somewhat higher when the iron is reduced with coke than it is in charcoal iron. Pig-iron with an amount of sulphur above 0·4 per cent. causes the production of red-short wrought-iron. All the better sorts of wrought-iron from Styria mostly contain only 0·02 per cent., and 0·04 per cent. at the highest. As the smallest amounts of sulphur render wrought-iron and steel red-short, both good wrought-iron and steel must be produced from pig-iron as free from sulphur as possible. White iron rich in sulphur cannot be converted into a fair wrought-iron, as its conversion takes a shorter time than is required for the removal of the sulphur; on the other hand, grey iron with a smaller amount of sulphur may be applied, although it never yields so good a wrought-iron as pig-iron free from sulphur. According to Karsten, even one 10-1000th part of sulphur renders wrought-iron somewhat red-short, but several thousandths are required to impair its applicability. Wrought-iron containing 0·02 per cent. of sulphur is no longer fit for punching. The superior sorts of steel may contain as much as 0·01 per cent. of sulphur.

Phosphorus is usually contained, in more or less quantity, in pig-iron, the iron ores, fluxes, or fuel being frequently contaminated with phosphates, and the phosphoric acid, upon the reduction and carbonisation of the iron, being reduced by carbon, as well as by metallic iron at a higher temperature than sulphuric acid, forming phosphide of iron. Whilst a certain amount of phosphorus renders wrought-iron cold-short, injuring the quality of wrought-iron in a similar way to sulphur, it has been suggested that sulphur and phosphorus present in wrought-iron at the same time might neutralise each other. Janoyer believes that the phosphorus removes part of the sulphur, forming sulphide of phosphorus, and Jullien supposes that the phosphorus tends to reconstitute the cohesion of the iron, which at a higher temperature was impaired by the presence of sulphur, but such iron is never so strong as iron free from sulphur and phosphorus, and the wrought-iron produced from it shows cold-shortness and red-shortness in a less degree, for the reason that upon mixing pig-iron containing sulphur with pig-iron containing phosphorus, the injurious substances are distributed throughout a larger mass. Phosphorus renders grey pig-iron harder and less strong than silicon, but only if the amount of phosphorus exceeds 0·5 per cent.; an iron containing a large amount of phosphorus is more thinly liquid than iron free from phosphorus; it is well adapted for castings, giving very sharp outlines, not requiring a further mechanical treatment, which would be rendered difficult by the greater hardness of the iron. The different sorts of grey iron contain from traces up to 1·5 of phosphorus, and even more—if containing 5·6 per cent. the iron is still fit for castings; it is light in colour, and has a fine grain and a compact texture. Grey iron, poor in phosphorus, is more or less fit for conversion into wrought-iron and steel, and very slight differences in the amount of phosphorus seem essentially to influence the quality of the iron, and particularly of the steel. A certain amount of manganese seems to assist the removal of the phosphorus, as, according to Struvé, at the puddling process phosphate of manganese is formed, which enters the slag, and is very difficult to reduce. Caron did not find manganese facilitated the removal of phosphorus. According to Karsten, 0·3 per cent. of phosphorus does not not impair the quality of wrought-iron; iron containing 0·5 per cent. stands the schlagprobe (this Mr. Röhrig translates "blowing test," but it more probably means the "percusssion test," or the test of allowing a weight to fall upon a bar of metal supported at the extremities), and iron containing from 0·75 to 0·80 per cent. shows cold-shortness. Wrought-iron, containing 1 per cent. of phosphorus, can be applied to but few purposes. White pig-iron, rich in phosphorus, always yields inferior wrought-iron, and is never, therefore, intentionally produced. Good white forge-iron, produced from purer ores and spiegeleisen, scarcely contains even traces of it; such traces are even found in iron produced from ores perfectly free from phosphorus; they are introduced by the ash of the fuel. Most varieties of steel of high repute contain from 0·01 to 0·02 per cent.; and, though showing some cold-shortness, wrought-iron containing from 0·25 to 0·30 per cent. of phophorus is still fit for various fine-forge purposes.

There are various theories concerning the influence of nitrogen on steel. Whilst Frémy and Boussingault consider nitrogen as an essential component of pig-iron, Caron and Gruner believe it to be an accidental component, as when undergoing analysis iron in a pulverised state combines easily with ammonia. Buff found 0·26 per cent. of nitrogen in pig-iron produced from bog ores. Schafhäutl ascertained that nitrogen is an essential component of all sorts of English white iron; he also found in grey cast-iron from Creusot, 0·7202 per cent.; in English cast-steel, 0·1831; and in spiegeleisen, 1·20 per cent.; but he only discovered mere traces in some varieties of German iron. Rammelsberg found more recently only 0·002 per cent. of nitrogen in spiegeleisen, which, although again proving that nitrogen combines with iron, leaves it doubtful whether its pressure is essential to the physical properties of the iron. Manganese contained in the iron ores or fluxes is reduced with much more difficulty than protoxide if iron; it produces slags easier to fuse, and consequently white pig-iron, which may become spiegeleisen if the ores employed are pure; moreover; it purifies the iron by forming chemical combinations with silicon, sulphur, &c., which separate on the surface of the liquid iron. Spiegeleisen, then, contains a proportionally small part of the manganese (usually only 7 per cent.) reduced in the furnace, which, however, under certain circumstances may increase to 22 per cent. and more. The presence of manganese in pig-iron does not appear to exert much influence either for good or for bad on the quality of the metal; and even when it exists in quantity, amounting to 4 or 5 per cent. in the crude iron, it disappears almost entirely during the conversion of the cast-iron into malleable or wrought. The cinder from iron smelted from manganesiferous ores contains, generally speaking, more sulphur than slags or cinders from iron ores containing no manganese. As grey iron results from ore mixtures which are more difficult to fuse than similar mixtures for white iron, the former mixture must not contain any perceptible amount of manganese, or it must be melted with an admixture of lime containing magnesia, if the production of grey iron is intended. A certain amount of manganese renders such grey iron harder (probably owing to the formation of silicide of manganese), mottled, and less fit for some kinds of casting than pig-iron containing sulphur. According to Karsten, 1·85 per cent. is the highest amount of manganese which wrought-iron may contain without deterioration in quality.

The influence on the quality of iron, cooper, arsenic, tin, zinc, and other metals is also considered. According to Eggertz, some tenths per cent. of copper render iron red-short, and steel is more sensitive to the effect of copper; therefore the Swedish iron ores, being free from copper pyrites, are particularly fit for the production of pig-iron for steel manufacture. Wrought-iron containing 0·5 per cent. of copper shows traces of red-shortness, whilst steel produced from such iron was useless. Schafhäutl is of opinion that the noxious influence at the puddling process does not exist; moreover, that it is chiefly the state of aggregation, and also the metalloids mixed with the carbide of iron, which exert the greatest influence. Arsenic, like phosphorus, renders pig-iron hard, brittle, and of great fusibility, and wrought-iron cold-short and difficult to weld. Schafhäutl states that a certain small amount of arsenic—perhaps present in the form of arseniuretted carbon—renders steel fine grained, and of greater strength; a greater amount of arsenic causes red-shortness. Antimony and bismuth behave like arsenic; an amount of 0·3 per cent. of arsenic renders wrought-iron cold-short. Antimony, arsenic, and bismuth volatilise at the welding heat of wrought-iron. Pig-iron containing tin has a fine-grained steel-like texture, a clear sound and great hardness, without being brittle in excess, and it is easy to fuse. A cold-short wrought-iron containing about 0·19 per cent. of tin is produced from pig-iron containing 1 per cent. of tin; upon heating it is easy to forge, and emits a white vapour. Iron containing a larger amount of tin is difficult to weld during the puddling process; it causes a great loss of iron, and yields wrought-iron so cold-short that it breaks like glass merely on falling; this wrought-iron also welds badly; its fracture is fine-grained, white, and dull. Calamine or zinc blende in the iron ores introduces but little zinc into the iron—most of it volatilising. A considerable volatilisation of zinc may carry off so much heat as to cause the formation of white iron; zinc also requires a considerable quantity of fuel for its reduction and volatilisation. Galena associated with iron ores has no influence on the pig-iron; part of it volatilises, and part is found in a metallic state beneath the sole-stone of the blast-furnace, its contents of silver being concentrated in it.

Vanadium, molybdenum, chromium, tungsten, and titanium are found only in small quantities in pig-iron, and seem to influence its quality but slightly; the improvement attributed to the use of titaniferous ore is probably due to some indirect action rather than to the actual presence of titanium in the finished product. A larger amount of titanium renders the ore mixtures more difficult to fuse, owing to the impeded carbonisation of iron, as the titanium combined with iron unites with carbon, and separates in the shape of copper-red cubical crystals, which consist of cyano-nitride of titanium. An addition of fluxes containing potash renders a titaniferous mixture easier to fuse; a certain amount of lime and silica serves the same purpose, forming a combination of silicate and titanate of lime, which is easier to fuse. About 1 per cent. of titanium may be present in pig-iron; it increases the strength of the metal, at the same time giving it a peculiar mottled character, the fractured surface showing a series of dark-grey patches, apparently set in white network. Nickel and cobalt seldom occur in iron; nickel alloys readily with iron, without affecting its malleability; cobalt is said to increase the whiteness and brilliancy of iron, but has no marked effect upon its physical properties. Aluminium, calcium, and magnesium are reduced in small quantities by the influence of the temperature of iron blast-furnaces, if the slag present be basic; they then enter the pig-iron. Larger amounts of these metals injure the quality of the pig-iron as well as that of the wrought-iron produced from the pig-iron; on the other hand, they are said to improve the quality of steel. Schafhäutl considers silicide of iron and aluminide of iron as characteristic components of grey iron, and carbides of silicon, copper, and arsenic as components of steel. Alkali metals, sometimes contained in the ash of the fuel or in the flux, and also in some iron ores, are reduced and alloy with the pig-iron. According to Tissier, they have a favourable influence during the conversion of the pig-iron into wrought-iron, as they combine directly with sulphur, phosphorus, and arsenic, thus separating these substances, and as they oxidise silicon and carbon if present in the oxidised state. The better quality of malleable iron produced from charcoal in comparison with that made from coke pig-iron is said to be partly caused by the presence of an alkali metal. At Witkowitz trials were made to add some chloride of sodium to the iron, but without success, owing to the volatility of the salt. Tapping the pig-iron into moulds coated with common salt, soda, or potash was also unsuccessful.

In subsequent chapters such subjects as the chemical constitution of pig-iron, smelting materials, the various treatment of ores to prepare them for the smelting process, blast-heating apparatus, conduct of the blast-furnace process, and indication of the working condition of the furnace, methods of making wrought-iron, fuel, fluxes, puddling apparatus, &c., are treated, all necessary details bearing upon each point being carefully given. Referring to the production of wrought-iron in the puddling process, it is remarked that the consumption of fuel depends on the nature of the coke and pig-iron, and on the construction of the refinery hearth. When running the liquid pig-iron into the refinery, the consumption amounts to 4 cwts. of coke per ton of fine metal with forge pig, and to 5 cwts. with grey pig-iron; and it amounts to from 6½ to 8 cwts. when charging the refineries with cold pig. The whole process as practised in various works and districts is carefully described, and there are good accounts of the manufacture of tin-plates, of wire drawing, and of various

* "A Practical Treatise on Metallurgy." Adapted from the last German edition of Prof. Kerl's Metallurgy. By William Crookes, F.R.S., and Ernst Rohrig, Ph.D. In three volumes. Vol. II.: Copper, Iron. London: Longmans, Green, and Co.

other matters ultimately connected with the manufacture of iron. The volume, as a whole, is undoubtedly valuable, and if there be any grounds for the assertion that there is a lack of technical knowledge amongst the industrial classes it need no longer exist; for from this book an intimate acquaintance with all that is being done on the Continent may be readily acquired, and a sound practical opinion formed of the relative merits of the various processes and of their adaptability to any ores it may be desired to treat. The work, when completed, will be a thorough metallurgical encyclopædia.

THE LAW OF PATENTS.

It affords us much pleasure to introduce to our readers a new treatise on this subject* from the pen of our old and esteemed correspondent, Mr. F. W. CAMPIN, than whom there is no man in this country better qualified to afford correct information regarding our Patent Laws.

The present treatise is in every way worthy of Mr. Campin's reputation as a patent lawyer, and although written in a style readable and understandable by non-legal men, is as comprehensive and definite as the most technical of law books.

Early in the work Mr. Campin defines "Patentable Invention" according to law, in regard to which he states the terms of the Statute of Monopolies referring to this point—namely, that it must be comprehended by the words "any manner of new manufacture," as used in that statute, which he interprets as referring to the "mode, method, or way of manufacturing, rather than the kind of thing manufactured. For example, the art of glass making—that is, the manner or process adopted in making glass—certainly constitutes one of the manufactures; whereas the product, glass, is in exact terms not one of the manufactures, but an *article* of *manufacture*." He adds—"Moreover, such a construction of the words of the statute will be found to be supported by the common law dictum"—namely, the decision of the judges antecedent to the statute—"that the patent must be for a 'new trade,' the word trade, as thus used, evidently meaning mechanic or industrial arts exercised in the way of trade, for any other meaning of the word trade, as so used, is not consistent with the words *or any engine tending to the furtherance of a trade*, as used thereafter." And Mr. Campin adds—"In short, it must be considered, as the late Mr. Hindmarsh justly remarked, it was intended the patent should relate to the exclusive right to practise 'an art,' although this art might possibly be only an improved phase of some other known art."

Mr. Campin, in proceeding with the treatment of his subject, details the formalities to be observed in obtaining patents, and the requirements of the law as to Provisional Specifications, which he considers to be more than sufficiently latitudinarian, for although, as he states, the Patent Law Amendment Act of 1852 requires that document to state "the *nature* of the invention," yet it would seem that the attempt of Lord Chancellor Westbury to effect a stringent application of the enactment, in the case of Foxwell *v.* Bostock, A.D. 1864, in reference to Judkin's sewing machine patent (10, Law Times Reports, 144) has not found favour with his judicial brethren. For he says—"The case of Penn *v.* Bibby, an appeal to Lord Chancellor Chelmsford (2, Law Reports, Chancery Appeals, 127), with reference to wooden bearings for propeller shafts, decided that although the provisional specification may be couched in vague and general terms, as in that case for the 'employment of wood' for the purposes described, yet if those terms be true as far as they go, and the Royal law officers pass the document as sufficient, their vagueness ought not to be questioned in the Courts." And, in that case, the above general statement, "employment of wood," for the purposes described, which would mean its employment in *any kind of manner*, would, however, have been too large, and not novel, whereas it was claimed in the *Final* Specification the invention was restricted to the construction of wooden bearings for propeller shafts, by making such bearings *with grooves or channels* provided therein, into which the water might flow freely. And the cases of Newall's and Thomas's patents are shown to operate in support of the decision in Penn *v.* Bibby. Mr. Campin, however, advises every inventor not to rely too much on the liberality of judicial construction, but so to frame the provisional specification as not to affirm anything to be of the essence of the invention which cannot fairly be developed in the final specification in terms consistent with the provisional specification.

There is a very instructive chapter, in which the subject of Opposition to Patent Applications is dealt with; this being, according to Mr. Campin's views, an unsatisfactory part of the law. The Complete or Final Specification is treated of in a concise yet pertinent way, and much useful information is given as to the legal Nature of Patent Property, the requirements of the law as to Assignments and Licenses, as to Infringements and Repeal of Patents, as to Prolongations and Confirmations, as to Amendment of Specifications, and all other points of patent law are referred to, and the citation of cases occurs at every step. The Patent Law Amendment Act is fully recited, and the whole of the Rules and Regulations of the Commissioners, together with the necessary forms, are given in the book.

The work is one of Weale's series, and its price is only 2s. We recommend all inventors and patentees, and manufacturers and dealers in patented articles to buy the book and read for themselves. At a future time we hope to be able again to return to the work.

* "The Law of Patents for Inventions; with Explanatory Notes on the Law as to the Protection of Designs and Trade Marks." By F. W. CAMPIN, Barrister at Law (Gray's Inn). London: Virtue and Co.

FOREIGN MINES.

ST. JOHN DEL REY.—The directors have received the following report, dated Morro Velho, March 17:—Morro Velho produce for February, 9773 oitvs., from 5271 tons of ore; yield, 1·854 oitvs. per ton. Morro Velho cost for February, 4526*l.*; loss for ditto, 747*l.* Morro Velho produce, 11 days of March, 3106 oitvs.; yield, 1·712 oitvs. per ton. Gaia produce for February, 813 oitvs., from 856 tons of ore; yield, ·949 oitvs. per ton. Gaia cost for February, 467*l.*; Gaia loss for ditto, 119*l.* Gaia produce, 11 days of March, 336 oitvs.; showing a yield of 1·021 oitvs. per ton.

DON PEDRO.—Mr. F. S. Symons reports for February:—Produce, 22,726 oitvs., at 8s. 6d. per oitava, 9658*l.*; cost, 2736*l.*; profit, 6922*l.* With a short month I have the pleasing duty to report a first-rate produce, exceeding that for January by 2758 oits. The lode has yielded first-class work; our attendance has been good, as well as the supply of materials, and, though nothing new has been discovered in the exploratory works, the result of the month's operation has been highly satisfactory.—First division of March. Extract from Mr. F. S. Symons' letter, dated March 17: "Produce cleaned to date, 12,467 oits. I am very pleased to report that the Californian pumps have been fixed, and sinking again commenced. The lode, as we extend in depth, as yet is improving in quality. Box work has been taken from lines in 'curve' as well as from reserve underlie lode to the north of No. 4. To date our reserves of ore have been much more auriferous than expected."

ANGLO-BRAZILIAN.—Mr. F. S. Symons reports for February:—Produce, 1816 oits., at 9s., 817*l.*—Cost, 1409*l.*: loss, 592*l.* The weather and sick list have been favourable, the attendance of the force has improved, and the works generally have been carried on satisfactorily. But I am sorry to advise no amelioration has taken place in the condition of the lodes. Killas is still the predominating element, and owing to this untoward circumstance the results of the month's proceedings are but little better than those for January.—First division of March: Extract from Mr. F. S. Symons's letter, dated March 17:—The works both in and out of the mine are proceeding with regularity, and a fair supply of mineral has gone through the stamps. The features of the lodes are without alteration, though at Dawson's south and Foster's there is an improvement. Killas continues plentiful at other sections. Operations are being continued at the Gongo Mine; the lode is large, but I am unable yet to report as to its auriferous quality.

SAO VICENTE.—The following has been received from the company's superintendent in Brazil, dated March 17:—From previous letters you will have learnt that our explorations at present are confined principally to exploring the jacotinga formation, and in laying open the quartz lode in the eastern section of this mine.—Jacotinga Formation: We are now extending our operations both eastward and westward upon the most promising lines met with as yet in this formation, but since my letter of Oct. 15, 1868, no gold has been seen in the samples taken. Whether the gold when seen came from a pipe vein crossing the jacotinga, or whether it came from the implements formerly used at the quartz lode, I cannot say; but, from the circumstance that no sign of gold has been seen since, I rather think the latter. The layers of jacotinga we are extending upon are very variable, at times being of a very promising character; and, as it is a well-known fact in almost every jacotinga mine that at a short distance from where rich shoots of gold have been met with, though on the same line, no sign of gold may be seen; therefore, it is possible that we may, from one month to another, or even one day to another, come upon something good.—Rock Formation: The lode in the eastern section, at Phillips's shaft, has somewhat since my last, and is now about 3¼ ft. wide. We have commenced to pass the ores through the stamps.

ROSSA GRANDE.—Mr. Ernest Hilcke reports for February—The produce for the month amounts to 624 oits. of gold. The works, both in and out of the mine, are progressing steadily, and good duty has been performed.—Gongo Mine: In sinking the new shaft we intersected an old level about 9 fathoms below the surface, and here the air became so bad that we were compelled to suspend our explorations. The machinery required to remove this foul air is nearly completed. More than a mile of close brushwood has been cut down in a westerly direction on the outcrop of unexplored jacotinga formation; this formation seems to extend still a great way further west. As soon as the woods are cleared away here we shall commence at various places to examine this jacotinga. The small veins we are working on in the mine have yielded during the month 66 oits.—Mina de Serra: The lode in general has again become more regular, and improved in size and appearance, yet its auriferous quality is not so good as in the previous month; the average percentage amounts only to 4·2 oitavas per ton.—Mina Alto: The lode here, I am afraid, is, so far as visible on surface, of a very low gold percentage. The result of extracting the more productive parts of the lode has not come up to expectations. It only yielded 1·8 oits. per ton.—First Division of March: Extract from Mr. Ernest Hilcke's letter, dated March 16: "Gongo Mine: The air-machine for the shaft is finished and put to work, and proves to be very effective. The old level intersected here is considerably crushed, and filled up with rubbish; we are securing and clearing out the same before sinking the shaft any further. Nothing of importance has occurred regarding the other places of operation.—Mina de Serra: The appearance of the lode has undergone no change since my last, and I think its auriferous nature is improving again."

TAQUARIL.—The information received by the directors shows that the most active exertions are being made to facilitate productive operations at the mines. Mr. W. H. Richards (March 15) says—"Mining Operations: I informed you in my last that this adit had been communicated to the engine-shaft. We have been occupied in timbering the circular shaft from the surface to this level, preparing timber for the plat, and in making the necessary arrangements for sinking the shaft below the shallow adit. The dimensions of the shaft will be 10 ft. by 6 ft. 6 in. within the timber, which will be 1 ft. square, and the poles 3 in. in diameter, adding 2 ft. 6 in. both to the length and width, so that it will be necessary to sink the shaft 12 ft. 6 in. in length, and 9 ft. wide. The sinking 11 fms. to reach the bottom of the old workings will not occupy us long when we once get the timberwork prepared, which will be ready before we shall be able to get the pumping machinery in order. Strakes for trying samples are now completed, and I shall to-morrow commence washing the jacotinga extracted from the old workings on a larger scale than hitherto; and as we can now ascertain the exact quantity washed, we shall be able to form a pretty correct estimate of its value. We have had several samples washed in the 'batea,' and they have all been very favourable."

[For remainder of Foreign Mines, see this day's Journal.]

AUSTRALASIAN GOLD.

The value of the Australasian gold imported into the United Kingdom in the two months ending February 28 this year was 658,586*l.*, as compared with 859,900*l.* in the corresponding two months of 1868, and 583,529*l.* in the corresponding two months of the year 1867. A number of quartz claims at Gympie (Queensland) have been registered, and work suspended until it is ascertained whether the claims in their immediate neighbourhood yield payable quartz or not, the impression now being that a considerable number of so-called reefs will not pay for working, as the auriferous stone is only found in thin veins. The Government of Western Australia has offered a reward of 5000*l.* for the discovery of a gold field within a radius of 150 miles from Perth, the condition being that 5000 ozs. of gold shall be obtained from that field, and cleared at the Customs for exportation before July 1, 1870. The receipts of gold by escort at the Sydney Mint from the gold fields of New South Wales amounted in 1868 to 229,738 ozs., valued at 894,830*l.* Of the whole quantity received, 131,944 ozs. came from the gold fields of the western district, 83,518 ounces from the southern district, and 14,276 ozs. from the northern district. The returns show an improvement of 7016 ozs. (due entirely to the increased production of the southern fields), as compared with 1867; further, a considerable quantity of gold reaches Sydney every year which is not included in the escort returns. The quantity of gold obtained from the Victorian gold fields last year was 1,274,061 ozs., of which 1,248,704 ozs. were exported. These figures show some decrease, as compared with 1867, and the falling off is accounted for on various grounds. In some districts there has been scarcely any water, in others the miners have been occupied in opening out fresh ground and deepening shafts, and there has been a considerable abandonment of old alluvial claims which have hitherto yielded good returns, but are now worked out. Increased attention is being directed in Victoria to quartz mining.

The recent crushings at the Thames (New Zealand) have been very good, and the prospects of that gold field are regarded as decidedly encouraging. The Provincial Government of Auckland has made arrangements for an advance of 10,000*l.* from the Bank of New Zealand, for the construction of various lines of tramways projected at the Thames gold fields. The plant, &c., is given as collateral security to the bank, and the advance is to be paid in three years. The material of the Auckland and Drury Railway has been transhipped to the Thames, and is to be utilised in the construction of the new lines. The quantity of gold upon which duty was paid at the various ports of Queensland in December, 1868, was 12,566 ozs. The revenue derived from gold by the Queensland Government was 25,588*l.* in 1868, as compared with 5287*l.* in 1867. There are now three gold fields in New Zealand—Otago, the Thames (Auckland), and Hokitika. The gold exported from Hokitika during the March quarter of 1867 was 68,000 ozs.; during the June quarter, 56,000 ozs.; during the September quarter, 57,000 ozs.; and during the December quarter, 62,000 ozs. In 1868 the export was—for the March quarter, 40,000 ozs.; for the June quarter, 40,000 ozs.; and for the September quarter, 38,000 ozs. The falling off in the production of the Hokitika fields is attributable to their comparative desertion for the Otago and Thames fields during the last 12 months. In 1863 Otago exported 580,000 ozs. of gold; in 1864, 455,000 ozs.; in 1865, 253,000 ozs.; in 1866, 162,000 ozs.; in 1867, 140,000 ozs.; and in 1868 about 150,000 ozs.

MINING IN AUSTRALASIA—MONTHLY SUMMARY.

MELBOURNE, MARCH 2.—Had we not become long ago dulled to anything in the nature of a surprise coming to us from the gold fields, we should have extracted a little more discussion about our last wonder in gold. Until recently Ballarat could boast of having produced the largest lump of gold (some 137 lbs. weight) on record, but now that is thrown quite into the shade by a mass of 210 lbs. weight, troy, unearthed by two miners, named John Deason and R. Oates (poor Cornish men), about three weeks back. It was found only about 2 in. beneath the surface, and at one of our earlier gold fields in the Donolly district, which has been well dug over for many years past. The lucky finders of the prize at once transferred it from its native bed to a dray—it was described as a tolerably heavy lift for two men—and took it off to the local branch of the London Chartered Bank, by whose manager it was bought for the sum of 9500*l.* The men were offered 9000*l.* for it at a venture before weighing, but the result proved their sagacity in declining even that apparently handsome sum. It has been melted down (losing only 7½ dwts. in the process), and probably it goes to England in the mail steamer which carries this letter. Some natural regret has been expressed here that only a rough drawing (but no model) has been taken of this, the greatest curiosity which our gold fields have ever yet yielded. At the same time it is very curious to observe how very little surprise has been expressed at the discovery itself. Apparently we have been talking about tons of gold until we have become comparatively insensible to mere hundredweights.

MINERAL CAOUTCHOUC.—Recent communications from Adelaide have made known the discovery in the southern portion of the colony of a remarkable carboniferous substance, which hitherto has only been found in small quantity in the coal strata of Derbyshire. It is a mineral caoutchouc, so called from its general appearance and some elasticity. In Australia it is found on the surface of the sandy soil, through which it would appear to exude from beneath, as, burnt off occasionally by the bush fires, it is again found after the winter season, occurring in quantity and of various thickness. Analysis proves it to contain 8⅓ or more, per cent. of a pure hydro-carboniferous oil; it value for gas-producing purposes would, there, be great, and it is also believed to be applicable to the manufacture of certain dyes. The discovery is also important from its indication of the existence of oils or other carboniferous deposits beneath the surface.

NEW MACHINERY FOR ALMANDA.—The directors of this mine appear to spare no pains in obtaining the very best machinery for crushing the ore, large quantities of which are available. A new powerful engine is to be erected at once, and orders for the necessary boilers were entrusted to Mr. Lindsay, the well-known maker at Port Adelaide. They are of large size—28 ft. long, and weighing over 9 tons each. Arrangements have been made with Messrs. Darton and Co. for their conveyance to the mine.

YORKE PENINSULA.—The Wallaroo Times of Feb. 27 says—The greatest activity prevails in mining matters on the peninsula. It is said that never before were so many men employed at either Moonta or Kadina. It is not only at the large companies that progress is being made and success met with, but several young mines are daily increasing in importance. The Moonta Company is now employing quite a little squadron of the aborigines at surface work, and both it and the Wallaroo Company are rather retarded by the scarcity of skilled labour. Another splendid lode has been discovered on the Moonta Company's property, thereby considerably enhancing its former value, and a suburban mine belonging to the Wallaroo Company, called the Wandilta, is fast developing into an important and valuable property. Last week the Paramatta shipped 500 tons of ore, and there exists every probability of largely increased yields from this mine. Of a number of smaller mines it may be said the shareholders are sanguine, the officers confident, and the general public hopeful.

ORE-CRUSHING MACHINERY.—Mr. Isaac Bailey, a gentlemen of large experience in silver mining, has arrived under engagement to test in a more satisfactory and complete manner than can be determined by assaying alone the value of the argentiferous deposits on the claims adjoining the Almanda. The machinery consists of a 10-horse power engine, and a couple of iron pans, in respect of which Mr. Bailey holds a patent for amalgamating. We understand the efficacy of the patent has been fully proved at the celebrated Nevada Silver Mines, where it has been extensively brought into operation. The machinery is equally adapted for quartz crushing as for silver ore, and will no doubt be extensively used to test the richness of the reefs at the Barossa or Jupiter Creek gold diggings.—*South Australian Register.*

AUSTRALIAN MINES.

YUDANAMUTANA COPPER.—The superintendent (March 2) states that acting under the board's instructions, not to remit to this side until the bank liability was cleared off, he should make no remittance by this mail.—Port Augusta Railway: Mr. Fuller's tender has been accepted, and the surveyors are preparing the plans. In consequence of a serious falling off in the copper returns, owing to the refusal of the smelters to work during the Christmas and New Year's holidays, I engaged and sent up a fresh party of smelters, and upon my arrival at the mine I found a great improvement. I remained at the mine a week, being at the works day and night, and during my stay 14 tons of copper was made, and 14 tons the following week, with four furnaces. In company with Captain Terrell I examined the whole of the workings, and have pleasure in confirming his report of Feb. 22, as follows:—Blinman Mine: The lode in the No. 1 winze is still looking rich. We have not been working the No. 2 winze for the month. The lode in the No. 3 winze is still holding good, from 5 ft. to 6 feet wide, good smelting work.—Main Shaft: The stopes north of No. 2 shaft, in back of the 25, are looking well, and greatly improved since my last report. The lode south of No. 1 winze, below the 10, is still holding good. The stopes in the big bunch continue as good as formerly. The total quantity of copper made in January was 46 tons 10 cwts. 3 qrs.; dispatched to port 48 tons 10 cwts. 3 qrs.; ore raised and smelted, 390 tons. This month I can only give three weeks' returns, owing to the departure of the English mail before our monthly returns arrived in Adelaide. Copper made for three weeks, 37 tons 10 cwts.; copper dispatched to port, 37 tons 18 cwts. 1 qr.; ore raised and smelted, 300 tons. Our fire-bricks are greatly improving, the last kiln opened being superior to any previously made. Firewood and charcoal coming in and keeping us well supplied. In conclusion, everything in the mine is going on satisfactorily.

WORTHING.—March 1: The engine-shaft is now down to the 93, and we shall at once commence to case and divide the shaft, and fix the plunger to that level. So soon as this is done to make ready for the water we shall cut the plat, and drive on to cut the lode, which I have no doubt will be a good one, from the appearance of the level above. The ground sunk during the month of five weeks is 13 ft. 9 in.; this is the most ground sunk in the shaft in a month since we left the 33. The way we account for this is that we cut a slide in the shaft, which appears to have changed the ground altogether. This I have been expecting for a long time, as you will see by my reports, where I speak of the white ground coming in from the north. Now, if this holds out, we shall not be long getting to the 100. The north end in the 83 has improved since last reported on; although it is not a first-class lode for ore, yet it will pay well for stoping after it has been driven through. Ground driven during the month, 22 ft. 9 in.; present price for driving, 14*l.* per fm. All the ground now driving north is new ground, standing from the 83 to surface, never touched, so that we have no idea of what we may meet with in driving the upper levels, so soon as we hole the north rise and winze. At present the winze and rise are both hard and rather poor, but improving in the winze. During the month we put a pare of men to stope the bottom of the 53 south, which will pay well south of the hard bar; but I am afraid we shall not be able to sink far, as the hard bar is keeping up the water. We have two men driving south in the 83 in the hard bar. We have a hard lode, but pretty good for ore. How long this will last I cannot say, as the ground is so very hard. The stopes throughout the mine are about the same as usual. Quantity of ore raised during the month, 230 tons; copper shipped, 16¾ tons; ore on hand, 123 tons, of 9 per cent., and 19 tons regulus of 50 per cent. Number of hands employed, 126.

PORT PHILLIP AND COLONIAL GOLD.—Mr. Bland (Clunes, Feb. 26):—The quantity of quartz crushed during the four weeks ending February 3 was 5098 tons; pyrites treated, 70 tons; gold obtained, 1760 ozs. 18 dwts., or an average of 6 dwts. 22 grs. per ton. The receipts were 6525*l.* 8s. 9d.; the payments, including the sum of 1725*l.* paid on account of firewood and timber contracts, 6151*l.* 14s. 2d.; the profit, 373*l.* 14s. 7d. Added to this was last month's balance of 1640*l.* 12s. 6d.; thereby making an available balance of 2014*l.* 7s. 1d. The amount divided between the two companies was 1200*l.*, the Port Phillip Company's proportion of which amounts to 780*l.* The balance of 814*l.* 7s. 1d. was carried forward to the next month's account. The return for the three weeks ending Feb. 24 is as follows:—Quantity of quartz crushed, 3584 tons; pyrites treated, portion of the above, 70 tons; gold obtained, 2019 ozs. 6 dwts.; or an average of 11 dwts. 6½ grs. per ton; remittances, 871*l.* 9s. 2d.

SCOTTISH AUSTRALIAN.—The directors have advices from Sydney (Feb. 26), with reports from Lambton Colliery to the 22d. The sales of coal for the month of December amounted to 12,394 tons, making 77,619 tons for the half-year ended at that date. For January, 1869, the sales amounted to 12,422 tons.

AUSTRALIAN UNITED GOLD.—Mr. Kitto (March 1) writes—Duke of Cornwall Mine: The quartz raised during the past month from the lode cut in the bottom level, in Daukes's shaft, fully bears out the opinion expressed in my last letter. The lode was got through on the evening of the day on which I last wrote. Thickness of lode 31 feet, consisting of quartz, decomposed slate, prian, and immense quantities of pyrites. Gold is visible in some instances in the cubes of the pyrites, but principally in the quartz rock. Although one cannot judge with accuracy in these matters, he may sometimes be pretty safe in giving an opinion. I anticipate the quartz from this level will yield at least 1 oz., or 4*l.*, to the ton. As we shall require a considerable quantity of stuff to keep the engine going when it starts, I have purchased a 25-horse power winding-engine (second-hand), and trust to have it fixed in time to supply the stampers with quartz. I trust to be able to report "getting up steam" in the large engine in my next despatch. The breaking away of the Government reservoir in Crocodile Gully in consequence of very heavy floods has caused considerable damage to ours. I have applied to the water department of the Government for compensation, and shall know the result of my application in a few days. In the meanwhile I must repair damages, to secure the work before winter. The injury to our work is not particularly serious, considering its original total cost.—Central Mine: The only work possible to be done here is the erection of the machinery, and this is being executed as rapidly as possible.

YORKE PENINSULA.—The directors have advices from the committee of inspection at Adelaide (March 1), by which they are informed it has been decided by the Government of South Australia to place the terminus of the New Burra Railway on the Bon Accord property, belonging to this company, and that from 15 to 20 acres of the surface will be required for that purpose, an arrangement which cannot fail to increase the surface value of that property. The shareholders of the company have taken up a sufficient amount of the debentures offered to them to justify the directors in ordering the resumption of operations at the Kurilla Mine, and a telegram was sent on the 12th to the committee at Adelaide, making absolute certain contingent instructions to that effect, which left London by the mail on the 26th ult. The board received advices by the mail which arrived in London in February last of the shipment, by the Duke of Sutherland, of 993 bags of ore of good per centage for copper raised from the Kurilla Mine. They have also advice of a sample bag of ore, per Glen Osmond, taken from a deposit of good ore in the top of the 35 east, which had been discovered dipping east shortly before the workings were suspended. Respecting this ore the committee write that it is "by far the best the mine ever produced." They state also, that it is the opinion invariably expressed by every competent person who has seen the mine that "at a greater depth far better results may be looked for if a sufficient number of miners be set to work upon it." The directors have very lately received a proposal to lease or purchase for the purpose of a "bush-man's home," 300 acres of the surface of the Bon Accord property, but have not thought it advantageous for the company to entertain.

ENGLISH AND AUSTRALIAN COPPER.—Advices received from the sub-manager, dated Port Adelaide, March 3:—The furnaces at the Burra were lighted on Feb. 8, and those at the Port were let out for a short time, to accumulate sulphurets to mix with the carbonate ores on hand. The quantity of fuel at the Burra was 600 tons, and at Port Adelaide 2700 tons. Further shipments of 100 tons copper had been made since date of last despatches.

BORING-MACHINE IN CORNWALL.—We are glad to hear they have at last agreed to use Dœring's boring-machine at Dolcoath, on the recommendation of the committee. Mr. Dœring is to be at the expense of placing the machine on the mine, and it is calculated they will be able to open up double the quantity of ground they could by hand labour. In the event of any dispute between Mr. Dœring and the adventurers, that gentleman, we understand, binds himself down not to institute legal proceedings; all disputes, we presume, to be settled by arbitration. Mr. M. G. Pearse, in his address, stated that he believed the boring-machine would be of incalculable benefit to the labourers as well as the adventurers, tending greatly to facilitate their work, and thereby to prolong life. The average duration of the miner's life is said not to exceed 40 years. We have reason to believe the introduction of the boring-machine will be of immense advantage in the way of ventilation, as well as in doing twice the amount of work in the same period of time.—*West Briton.*

SCIENCE AND ART.—A striking instance of the immense value a small piece of steel may acquire by the great power of skilled mechanical labour is the balance-spring of a watch. From its extreme fineness and delicacy 4000 weigh not more than one ounce, and exceed in value 1000*l.* A most interesting little work, describing the rise and progress of watchmaking, has been published by Mr. J. W. Benson, 25, Old Bond Street, and the City Steam Factory, 58 and 60, Ludgate Hill. The book, which is profusely illustrated, gives a full description of the various kinds of watches and clocks, with their prices. Mr. Benson (who holds the appointment to the Prince of Wales) has also published a pamphlet on Artistic Gold Jewellery, illustrated with the most beautiful designs of Bracelets, Brooches, Earrings, Lockets, &c., suitable for Wedding, Birthday, and other presents. These pamphlets are sent post free for two stamps each, and they cannot be too strongly recommended to those contemplating a purchase, especially to residents in the country or abroad, who are thus enabled to elect any article they may require, and have it forwarded with perfect safety.

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